EECS 16A Midterm 2 Review Session

Presented by <NAMES >(HKN)

Disclaimer

Although some of the presenters may be course staff, the material covered in the review session may not be an accurate representation of the topics covered in and difficulty of the exam.

Slides are posted at @# on Piazza.

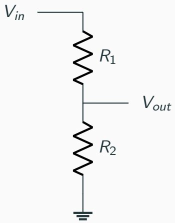
HKN Drop-In Tutoring

- These details should be written.

Loading

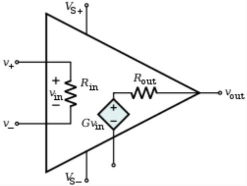
Circuit with loading: voltage divider

With voltage dividers: V_{out} depends on the **load**, or the *current drawn from the V_{out} terminal*.



Circuit w/o loading: op-amp

Ideal op-amps: V_{out} is **INDEPENDENT of the load**. The *internal voltage source* guarantees that V_{out} is **kept the same**. (*But the current produced from the output can be different*.)

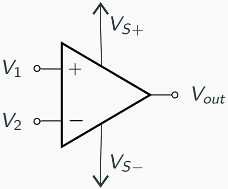


Op-Amp Configurations

Basic Op-Amp Configurations

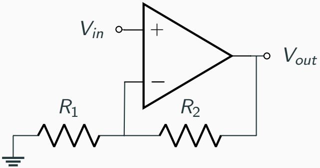
With **ideal op-amps**, you should use op-amp configurations as **building blocks** without regarding the effect of one block's R_eq on another block:

Voltage Comparator



$$V_{out} = \begin{cases} V_{S+} & V_1 > V_2 \\ V_{S-} & V_1 < V_2 \end{cases}$$

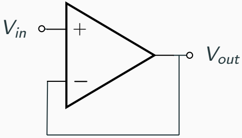
Non-Inverting Amplifier



$$V_{out} = V_{in} \cdot (1 + R_2/R_1)$$

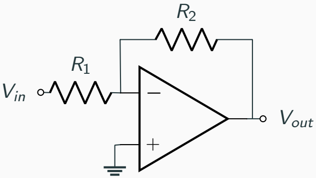
Basic Op-Amp Configurations

Unity Gain Buffer



$$V_{out} = V_{in}$$

Inverting Amplifier



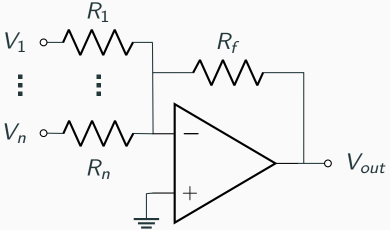
$$V_{out} = -V_{in}\frac{R_2}{R_1}$$

Also, look **here** for more useful op-amps configurations!

These might also show up on the final.

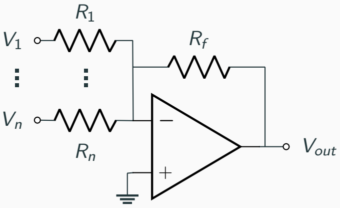
Practice: Op-Amp Analysis

Compute V_{out}:



(Hint: What basic op-amp configuration does this look like?)

Practice: Op-Amp Analysis [Solution]



This is similar to the **inverting amplifier**.

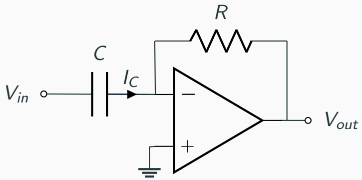
KCL at the negative terminal gives:

$$V_1/R_1 + \cdots + V_n/R_n = -V_{out}/R_f$$
$$V_{out} = -R_f(V_1/R_1 + \cdots + V_n/R_n)$$

Note that you can't use the formula for the inverting amplifier here because there are multiple voltage sources.

Practice: Calculus in Op-Amps!

Find V_{out} as a function of V_{in}:



Practice: Calculus in Op-Amps! [Solution]

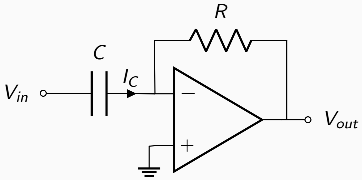
Notice that the circuit is in **negative feedback**:

By the first golden rule,

$I_c = C\frac{dV_{in}}{dt} - \frac{V_{out}}{R}$

By the second golden rule,

$V_{out} = -RC\frac{dV_{in}}{dt}$

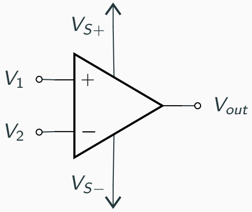


Deriving Op-Amp Configurations: Comparator

What is V_{out} when:

$V_1 > V_2$?

$V_2 > V_1$?

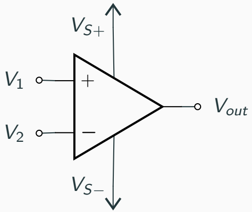


Deriving Op-Amp Configurations: Comparator [Solution]

What is V_{out} when:

$V_1 > V_2$? V_{S+}

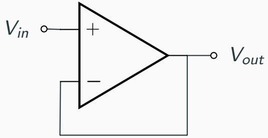
$V_2 > V_1$? V_{S-}



Reason: For *ideal op-amps*, the **gain is really large** (infinite). If there is a difference between V_1 and V_2, V_{out} will clip to the power rails.

Deriving Op-Amp Configurations: Buffer

Use the golden rules to find V_{out}.

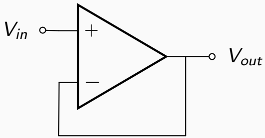


Use the golden rules to find V_{out}.

The op-amp is in **negative feedback**,
so $V_+ = V_-$

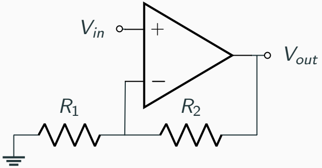
$V_{in} = V_+$ and $V_{out} = V_-$

So $V_{out} = V_{in}$.



Deriving Op-Amp Configurations: Non-Inverting Amplifier

Compute V_{out}.



Non-Inverting Amplifier [Solution]

Compute V_{out}.

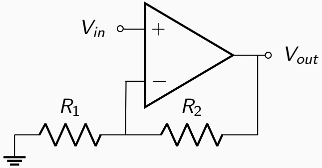
Apply **golden rules**: $V_{in} = V_+ = V_-$

Use **voltage divider**:

$V_- = V_{out} \frac{R_1}{R_1 + R_2}$

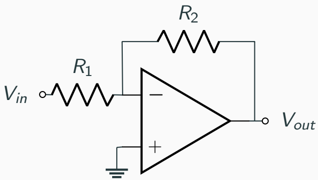
Combine and simplify:

$V_{out} = V_{in}(1 + R_2/R_1)$



Deriving Op-Amp Configurations: Inverting Amplifier

Compute V_{out}.



Inverting Amplifier [Solution]

Compute V_{out}.

Apply **KCL** at the negative terminal:

$V_{in}/R_1 + V_{out}/R_2 = 0$

So $V_{out} = V_{in}(-R_2/R_1)$